Impacts of waste management practices on water resources in Harare

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ABSTRACT: Poor municipal solid waste (MSW) management practices impact negatively on freshwater availability in terms of both quality and quantity. A review on the MSW practices currently being practiced and their impacts on water resources management in Harare was carried out to give recommendations towards sustainable MSW management and reduce the pollution of water bodies. There is urgent need for the development and implementation of a local level integrated MSW management plan tapping from the national plan that was pronounced in 2014. Such a plan should incorporate material and energy recovery with the best option combining anaerobic digestion of biodegradable MSW and incineration of the non-biodegradable MSW fraction. Legislative reforms to enforce source separation, the prohibition of dumbing waste at dumpsites together with the landfilling of biodegradable waste need to be urgently institutionalized.

1 INTRODUCTION

In developing countries, municipal solid waste (MSW) generation is increasing rapidly fuelled by the ever increasing population, economic growth, rapid urbanization and rising standards of living (Minghua et al., 2009). The increased municipal solid waste generation bring along challenges for municipal authorities to provide sustainable, effective and efficient MSW management systems due to increased burden of MSW management share on municipal budgets, limited knowledge on different factors affecting different waste management stages and the enabling links for the functioning of the entire MSW handling system (Guerrero et al., 2013).

Tsiko and Togarepi (2012) noted MSW management amongst the greatest challenges faced by Harare municipality due to increased MSW generation rate making it difficult for municipality to raise adequate financial and technical resources to match the growth in MSW generation. Poor MSW management practices directly and indirectly contribute to both surface and groundwater quantity and quality impacts that drive freshwater scarcity within a given catchment. Engelman and LeRoy (1993) reported as early as 1993 that perennial water scarcity challenges characterised many nations with Nhapi and Hoko (2004) reporting the urgent water quality problem and imminent water scarcity in Lake Chivero and Manyame catchment, the potable water sources for Harare city, Chitungwiza, Epworth, Norton and Ruwa.

Harare city, Chitungwiza, Epworth, Norton and Ruwa have been targeted for this study. They have a total population of 2,133.802 people, Harare at 1,485,231, Chitungwiza at 356,840, Epworth at 167,462, Norton at 67,591 and Ruwa at 56,678 people (ZIMSTAT, 2013). Population has increased from an estimated 1.4 million in 2002 (CSO, 2003) to over 2.1 million in 2012 (ZIMSTAT, 2013) showing an estimated annual average increase of over 70,000 people over the 10 year period. The 1992 census estimated Ruwa population at 440 persons (Zinyama, 1994, CSO, 2003) with the 2012 census giving an estimate of 56,678 people (ZIMSTAT, 2013) indicating an average annual increase of over 2,800 persons over the 20 year span. Epworth had an estimated population of just over 110,000 in 2002 (CSO, 2003) increasing to just over 167,000

people in 2012 (ZIMSTAT, 2013) thus an annual average increase of over 5,700 people. These population increases have not been matched with corresponding MSW management infrastructure and systems. This study therefore reviewed the impacts of prevailing MSW management on water resources management in Harare, Zimbabwe.

2 CURRENT MSW MANAGEMENT PRACTICES

MSW is defined as waste that is managed by or on the behalf of municipalities (Hester and Harrison, 2002, Kawai and Tasaki, 2016). It includes waste generated from household constituting between 55 to 80%, waste generated from markets and other commercial areas contributing between 10 to 30% and waste generated from institutions, industries and streets of varying contributions (Nabegu, 2010, Okot-Okumu, 2012). Annual MSW generation in the study area is estimated at over 400,000 tons. Harare, Chitungwiza and Epworth have an estimated annual MSW throughput of 421,757tons (Makarichi et al., 2019). Tirivanhu and Feresu (2013) reported an annual MSW generation of 371,697tons for Harare city, 90% of which has potential for either reuse or recycle.

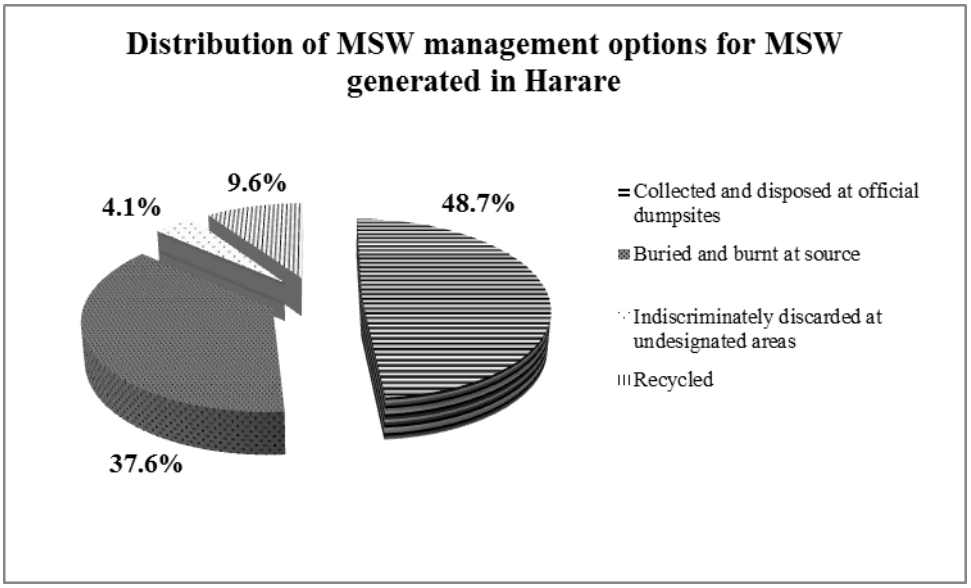

Figure 1. Management practices for MSW generated in Harare (EMA, 2016)

The Environmental Management Agency (EMA) (2016) observed that 48.7% of the MSW generated in the study area is formally collected and disposed at the three official dumpsites, 9.6% is recycled, 4.1% being indiscriminately discarded into undesignated areas with 37.6% being either buried or burnt at-source as shown in Figure 1. MSW collection was reported to have dropped from 52% in 2011 to 48.7% in 2016 (EMA, 2016) resulting in the accumulation of MSW awaiting collection.

Tevera and Masocha (2003) reported that at most 60 per cent of MSW generated in Harare is officially collected and disposed at dumpsites with the over 40% that remains uncollected usually discarded illegally in open spaces, alleys, storm water drains and road verges. The three formal MSW disposal dumpsites namely Chitungwiza, Pomona and Golden Quarry are unprotected and poorly managed without impermeable lining to prevent dumpsite leachate infiltration to the groundwater. The Government of Zimbabwe (GoZ) (2014) planned the construction of a sanitary landfill for Harare anticipated to have become operational by end of the year 2018. However, this has largely remained an idea with no actions on the grounds since the announcement of the National Integrated Solid Waste Management Plan in July of 2014 which provided for various intervention strategies from waste avoidance and minimisation, materials and energy recovery.

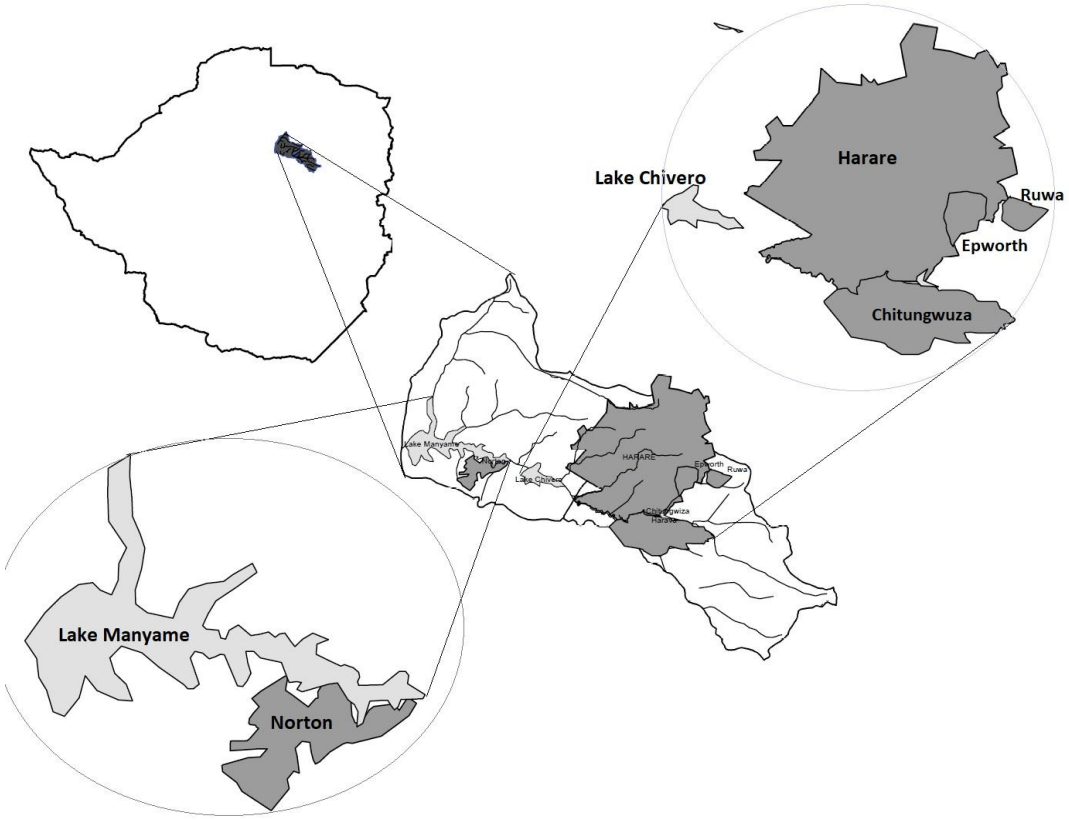

Figure 2. Urban environments located on Lake Chivero catchment

3 IMPACTS OF CURRENT MSW MANAGEMENT PRACTICES ON WATER RESOURCE MANAGEMENT

Four management practices for MSW generated in Harare have been identified namely, collec tion and disposal at official dumpsites, recycling, indiscriminate dumping in undesignated areas and the burning and burying at source. Amongst the four practices only material recycling is regarded not to have any harmful or negative impacts on water resources management. However material recycling must be expanded to other material constituents like glass, metals and others as it is currently limited to plastics and corrugated paper as noted by Makarichi et al (2019). The indiscriminate dumping of MSW in undesignated areas has negatively impacted the water situation in Harare leading to the annual and seasonal outbreaks of Typhoid and Cholera (Nhapi, 2009). MSW management problems in Harare are thus manifesting themselves through the pollution of both surface and groundwater emanating from the indiscriminate dumping of MSW in waterways and dumpsites leachate infiltration into groundwater. Although the discharge of raw or partially treated sewage into the river system that drains runoff from Harare has been cited as the major driver of the eutrophic status of Lake Chivero (Magadza, 2003, Rommens et al., 2003, Nhapi and Tirivarombo, 2004, Nhapi et al., 2004, Nhapi, 2014), hygiene breakdown in the urban environments result in nutrient rich surface run-off from uncollected MSW and illegal MSW dumps significantly contributing to Lake Chivero eutrophication (Magadza, 2003). This is largely due to the location of the urban environments within and surrounding Harare City namely Chitungwiza, Norton, Ruwa and Epworth on the catchment that drains runoff into the Lake as shown in Figure 2. This therefore entails for a holistic solution that encompass the rehabilitation of existing wastewater treatment infrastructure, construction of new wastewater treatment infrastructure complimented with sustainable and integrated MSW management system to avert the threats from MSW laded runoff from residential areas and other undesignated areas.

The eutrophication of Lake Chivero has led to increased costs for potable water production due to increased chemicals and power used during potable water production. Filter clogging

with colloidal algae calls for the need for filter backwashing using already filtered and partly treated water thus increased pumping and associated power for pumping during backwash and replenishing the water used during backwashing. In addition due to the eutrophic status of Lake Chivero, the City of Harare is forced to use nine chemicals namely powdered activated carbon, Aluminium Sulphate, High-Test granular Calcium Hypochlorite (HTH), Poly Aluminium Chloride, Poly Aluminium Chloride, Ammonia, Chlorine gas, White hydrated lime, Sodium Silicate and Sulphiric acid to treat raw water from Lake Chivero to meet potable standards. The 2017 City of Harare records shows that due to foreign currency shortages a third (US$12,886,268) was availed from the Reserve Bank of Zimbabwe against a planned budget of US$36 million to procure water treatment chemicals as shown in Table 1. Therefore, increased costs coupled with erratic foreign currency disbursements from the Reserve Bank of Zimbabwe have partly contributed to the erratic potable water supplies in most parts of Harare currently being experienced.

Table 1. Potable water treatment chemicals used by Harare city and their costs in 2017

Name of chemical	Unit	Unit cost	Total cost
	Metric tons	US$/kg	US$
Powdered activated carbon	598.08	1.67	983,763.60
Granular Aluminium Sulphate	1317.00	0.65	856,050.00
Liquid Aluminium Sulphate	18,990.88	0.49	9,305,531.20
Poly Aluminium Chloride (granular)	580	0.76	440,800.00
Ammonia	3.43	2.65	9,089.50
Chlorine gas	443.15	1.27	562,800.50
White Hydrated Lime	244.85	0.56	137,116.00
Sodium Silicate	165.03	0.82	135,324.60
Sulphiric acid	3.42	0.51	1,744.20
Bulk Sulphiric acid	381.02	0.42	160,028.40
High-Test granular Calcium Hypochlorite (HTH)	96.4	3.05	294,020.00
Total			12,886,268.00

Dumpsites leachate infiltrates into groundwater polluting an alternative source of potable water supply which a significant population has resorted to due to the prevailing potable water shortages. Sood (2004) noted the potential of open and controlled MSW dumps to significantly contribute to the pollution of groundwater sources. Rainwater infiltrates refuse due to the absence of top soil cover with water percolating through decomposing MSW absorbing chemicals together with micro-organisms present thereby contaminating groundwater as well as surface waters posing public health and environmental risks to residents. Love et al (2006) reported that both Golden Quarry and Pomona dumpsites lack the impermeable engineering lining for water sources leachate pollution prevention. Further observations by Love et al. (2006) at Golden Quarry showed that the concentration of coliforms, nitrates, iron, cadmium, and lead were unexpectedly higher than the World Health Organisation acceptable potable water quality standards in the entire Westlea neighborhood area rendering the groundwater unsafe for potable and other domestic uses. High metal concentration was attributed to the indiscriminate nature of MSW disposal with industrial waste also being disposed at Golden Quarry dumpsite. Lower metal concentration was observed at Pomona dumpsite as compared to Golden Quarry as less industrial waste is disposed at Pomona than Golden Quarry. The metals, nitrate and coliforms concentration at Golden Quarry decreased westwards in the direction of groundwater flow. Leachate pollution of groundwater and water bodies in the vicinity of both dumpsites must have reached unexpectedly higher levels now as more MSW is being generated and continuously dumped at these dumpsites despite the fact that they have reached their design capacity limits and degraded into potential human health and environmental hazards.

4 CONCLUSION

MSW management practices currently being practiced in the urban environments within and surrounding Harare City are highly unsustainable as they contribute to the outbreak of water borne disease, threatening human health, polluting potable water sources and undermining the integrity of the environment. The development of integrated MSW management systems incor-

porating material and energy recovery is now urgent coupled with the construction of an engineered sanitary landfill. The developed national integrated solid waste management plan has largely remained a plan without implementation as it did not provide estimates of budgets and resources needed to implement action plans which could be used for fundraising purposes. It is also important to develop strategies that nurture a culture of responsible citizenship i regards to MSW generation and changing mindsets and behaviors to address the indiscriminate throwing away of litter and unfinished food in undesignated areas. The Presidential Clean-up Day Declaration that made every first Friday of a calendar month a National Environment Cleaning Day is one such gesture by the highest office in the country anticipated to nurture this culture on responsible MSW handling by citizens. However, the monthly National Environment Cleaning Day need also to be complimented with tangible actions towards the prioritization of resource allocation towards the development of MSW management systems for municipalities since the waste that is being collected during the cleaning day is disposed at environmental unsafe dumpsites. Polluter pays legislation does exist and is subject to abuse as the polluting fines paid by polluters is not used for pollution remediation purposes as provided for in the legislation. There is need therefore for legislative adherence, enforcement and reform to facilitate waste minimization, source separation as well as the entry of private players into MSW management as current legislation gives MSW management mandate to municipalities only. However, municipalities can hire other private players to manage MSW on their behalf. Opportunities for biogas production exist considering the biodegradable content of MSW generated which is in the excess of 40%. Makarichi et al (2019) reported that the composition of combustible fraction in MSW generated in Harare exceeds75% by weight suitable for thermal treatment of MSW without adding supplementary fuel giving an annual energy potential of 3.8×10^6 GJ at a lower heating value of 10.1MJ per kg. This can possibly bring about a 40% reduction of MSW sent to landfills and providing almost 112 GWh per year of electricity. This will ultimately increase the annual share of MSW and biofuels derived electrical energy from 1.3% to atleast 2.2%.

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